



Alpy guiding User Guide

Olivier Thizy
(olivier.thizy@shelyak.com)

François Cochard
(francois.cochard@shelyak.com)



DC0017A : april-2013

Alpy guiding module User Guide



Olivier Thizy
(olivier.thizy@shelyak.com)

François Cochard
(francois.cochard@shelyak.com)

April 2013

Ref. DC0017 - rev A

Table of Contents

| | |
|---|-----------|
| Introduction | 5 |
| 1 Discover your Alpy guiding module | 7 |
| 1.1 Out of the box | 7 |
| 1.2 Alpy guiding specifications | 7 |
| 1.3 Alpy guiding principle | 7 |
| 2 Installing & tuning the Alpy guiding module | 11 |
| 2.1 Mounting the mirror slit on the Alpy 600 | 11 |
| 2.2 Assembling the Alpy 600 and guiding module | 12 |
| 2.3 Tuning the guiding camera | 13 |
| 2.4 Mounting the spectroscope on the telescope | 15 |
| 3 Observing with Alpy guiding | 17 |
| 3.1 Putting the star in the guiding field | 17 |
| 3.2 The star in the slit | 17 |
| 3.3 More light in the spectroscope | 18 |
| 3.4 Put the star (always) in the center of the slit | 20 |
| 3.5 Extended objects | 20 |
| 3.6 Conclusion | 20 |

Introduction

Alpy is a family of modular elements for astronomical spectroscopy. The Alpy guiding module allows faint objects to be observed (in slit mode) using guided long exposures .

Astronomical spectroscopy is quite easy, but there are a number of technical points to put under control. One thing is to master the spectroscope itself, another is to get the light from the object into the spectroscope. The Alpy guiding module is designed to make this part easy and efficient. Guiding means that you can continuously observe the spectroscope entrance (the slit) while acquiring a spectrum. It helps you center the star in the slit and then track it during the exposure. It ensures that most of light enters the instrument. Even if the quality of the spectrum comes from the spectroscope itself, it is very easy to lose 90% of the light with bad guiding - that's a pity, because astronomical objects are often faint, and the quality of your observation relies on the light intensity.

Auto-guiding

Guiding gives a large improvement in spectroscopy, however auto-guiding is even better. Auto-guiding means that you let the computer continuously analyze the guiding image and correct the telescope movement automatically. This of course makes observing more comfortable : you don't need to be looking at the guiding image all the time. But experience also shows that it significantly improves the quality of the observation, because the whole system always works the same way - and repeatability is a key for measurement quality.



It is important that you take some time to set up and tune the auto-guiding with your telescope : it will significantly improve the quality of your observations !

Equipment configuration

The Alpy guiding module is specifically dedicated to the Alpy 600 spectroscope. In this document, we will assume that you have an Alpy 600, and you're already familiar with this instrument.

The Alpy guiding module can be used with various equipment configurations, but we cannot document

all of them ! This documentation is based on a specific configuration (which perfectly matches the Alpy requirements). It will be easy for you to adapt the instructions to your own equipment & software:

- A Goto mount, able to point and track a star in auto-guiding mode.
- A C8 telescope with F/6.3 reducer.
- A CCD camera Atik 314L+ for acquisition.
- A CCD camera Atik Titan *for guiding*.
- A PC running under Windows 7 with Audela software.

You will find in the next chapters a presentation of the Alpy guiding module, how to install & tune it on the Alpy 600 and how to observe with it.

Astronomical spectroscopy is a never ending story. We've thought about a lot of applications (you can find some ideas on Shelyak Instruments website¹). However, we know that you'll invent new ones. We'll be very happy to take your experiences into account to continuously improve this product : do not hesitate to contact us if you have any comments !

We invite you to join the growing Shelyak Instruments users and amateur spectroscopist community on the Spectro-L Yahoo group ² and the Aras forum³ to share your own experience and ask questions to the community. We are really interested to see your results there.

Enjoy Spectroscopy !

Olivier Thizy⁴

François Cochard⁵

-
1. <http://www.shelyak.com>
 2. <http://groups.yahoo.com/group/spectro-l/>
 3. <http://www.spectro-aras.com/forum/>
 4. olivier.thizy@shelyak.com
 5. francois.cochard@shelyak.com

Discover your Alpy guiding module

1.1 Out of the box

When you receive your Alpy guiding module, you'll find in the box the following parts:

- The Alpy guiding module itself,
- The mirror slit,



1.2 Alpy guiding specifications

Table 1.1 gives detailed specifications of Alpy guiding. Figure 1.1 shows all dimensions.

Mechanical interfaces

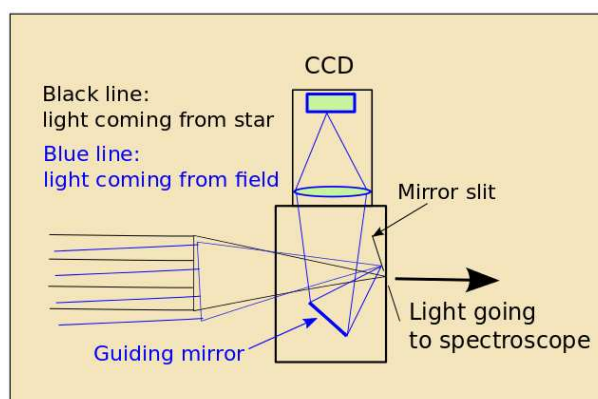
The Alpy guiding module has several standard interfaces. You can use them to adapt it to your configuration.

The main cube contains two T-mount threads (M42 x 0.75mm), one for attaching the spectroscope, the other one towards the telescope. The guider external body also has a T-mount thread. The CCD guiding port is a C-mount thread (1", 32 threads/inch):



1.3 Alpy guiding principle

The principle of the Alpy guiding module is described in the figure below. The light beam coming from the star (collected by your telescope, on the axis) is focused on the slit plane of the spectroscope. After going through the slit, it continues towards the spectroscope. Another light beam, not exactly on the axis is reflected by the slit (manufactured with a mirror surface) at an angle towards the guiding mirror. The guiding mirror sends it towards the guiding optics, perpendicularly to the telescope axis, and finally to the guiding CCD:



The guiding optics consist of two achromat doublets which transfer the slit plane image to the guiding CCD.

| Feature | Value | Unit | Comment |
|----------------------------|-----------|---------------|--|
| Dimensions | 90x65x75 | mm | see fig. 1.1 below |
| Weight | 260 | g | without guiding CCD camera |
| F-ratio for guiding optics | 1:1 | - | |
| Guiding camera mount | C-mount | - | Backfocus 17.5mm, can be extended to CS-mount (12.5mm) with an optional extender |
| Guiding CCD max size | 9,5 x 7,5 | mm | same as field size in focus plane |
| Slit width | 23 | μm | mirror slit |
| Slit length | 3 | mm | |

Table 1.1: Alpy guiding specifications

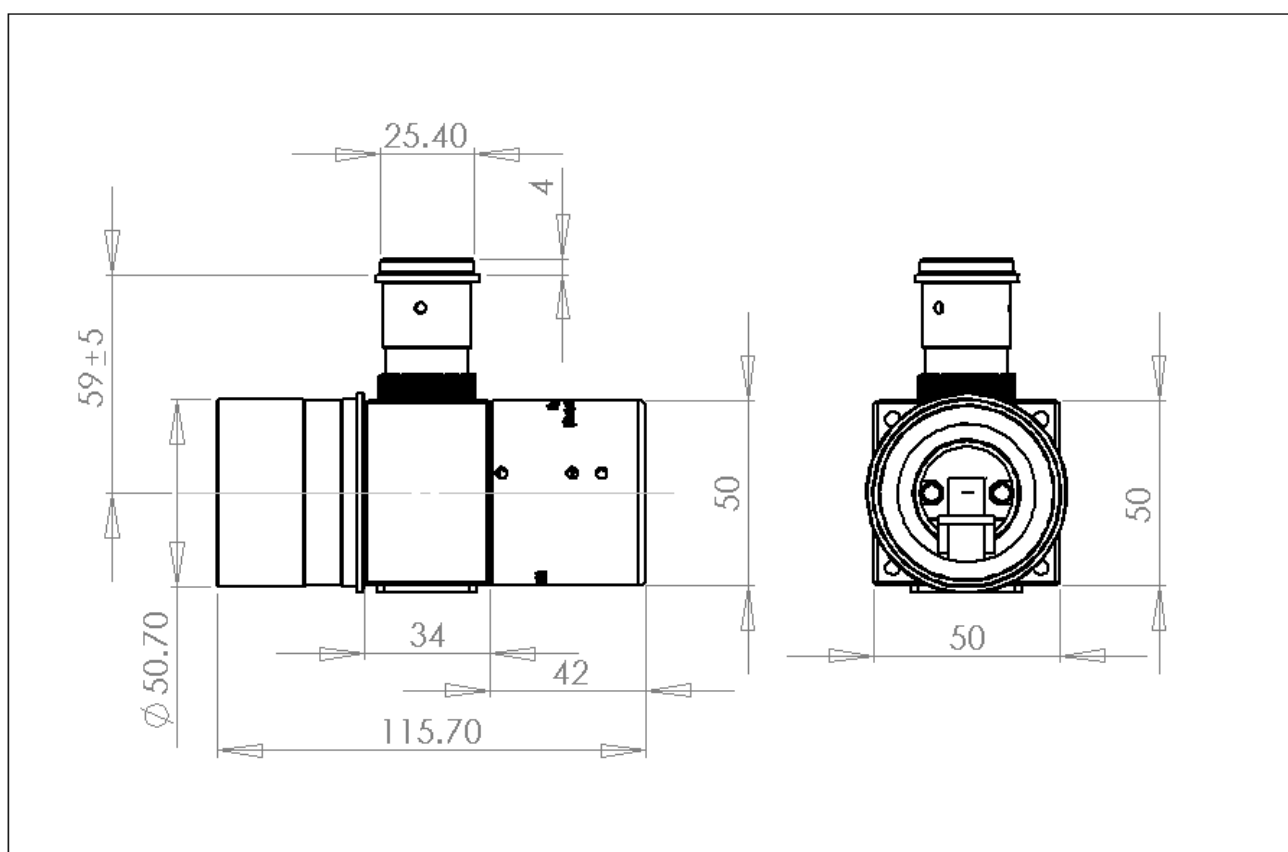
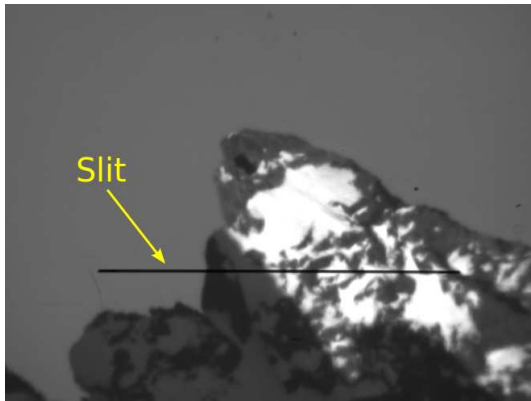


Figure 1.1: Alpy guiding dimensions

In the CCD image, you can then see the telescope field, and the slit (black line in the image below)



As a result, all the light which passes through the slit is spread out and analyzed by the spectroscope and all the light outside the slit is sent to the guiding CCD. In ideal conditions, when the telescope is aligned on the star, you should not see it any more in the guiding image. But in practise, you'll always see some of the light - it is almost impossible to send 100% of the starlight through the slit.



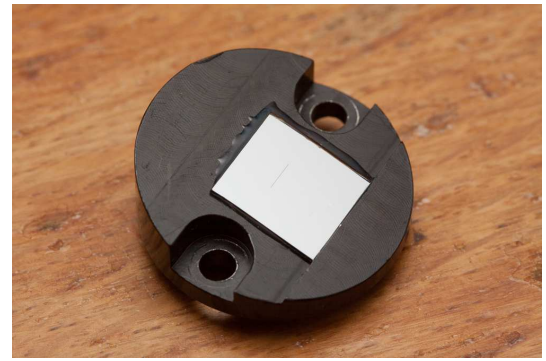
When looking at the guiding image, the less light you can see in the guiding image, the more is sent to the spectroscope (this is only true if the camera gain and image visualization thresholds are constant).

The slit plane is the key location of your instrument. This is the focal plane for three elements : the spectroscope, the guiding camera and the telescope. In practise, we always recommend tuning these elements in this order:

1. Spectroscope
2. Guiding image
3. Telescope (based on the guiding image)

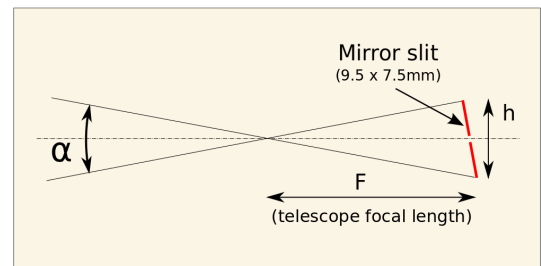
Mirror slit

The Alpy 600 spectroscope is shipped with a standard slit. This slit is not reflective and cannot be used for guiding. For this reason, the Alpy guiding module is shipped with its own reflective slit. This is a $23\mu\text{m}$ slit - optimized for the Alpy 600.



Field of view calculation

It is sometime useful to calculate the Field Of View (FOV) of your guiding system. It depends not only on the Alpy guiding module optics, but also on your telescope focal length. The useable area of the guiding slit is $9,5 \times 7,5 \text{ mm}$. If the guiding CCD is bigger than this size, the size of the slit limits the FOV (this is the max FOV). If the CCD is smaller, then this limits the FOV. In that case, use the CCD dimension instead of the mirror slit dimension.



In most cases, the FOV is limited by the guiding CCD size.

The max FOV for your telescope focal length (F) is:

$$\alpha = 2 \times \arctan\left(\frac{h}{2F}\right)$$

where h is the size of the slit field.

For instance, if your telescope has a focus length of 1280mm, max FOV width is

$$\alpha = 2 \times \arctan\left(\frac{9,5\text{mm}}{2 \times 1280\text{mm}}\right) = 25,5'$$

Here is the max FOV (in arcmin) for typical telescope focal lengths (FL):

| FL (mm) | width | height | diagonal |
|---------|-------|--------|----------|
| 500 | 65,3' | 51,6' | 83,2' |
| 800 | 40,8' | 32,2' | 52' |
| 1000 | 32,7' | 25,8' | 41,6' |
| 1280 | 25,5' | 20,1' | 32,5' |
| 1500 | 21,8' | 17,2 | 27,7 |
| 2000 | 16,3' | 12,9' | 20,8' |
| 3000 | 10,9' | 8,6' | 13,9' |
| 4000 | 8,2' | 6,4' | 10,4' |

2

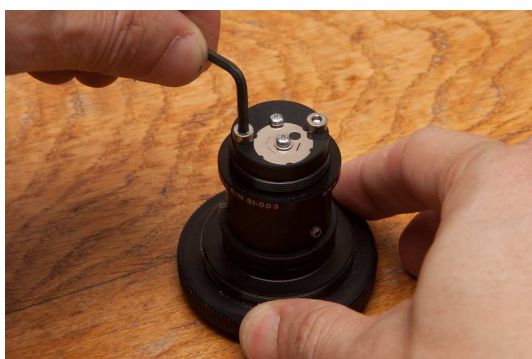
Installing & tuning the Alpy guiding module

2.1 Mounting the mirror slit on the Alpy 600

Remove the external body from the Alpy 600; it will not be used with the Alpy guiding module:



The Alpy 600 spectroscopy has a removable slit holder. Remove the two screws, then the holder:



Replace it by the guiding slit. There is no specific orientation:



The nominal thickness (base to slit) of the standard and guider slit holders are identical (5mm). However, there is some manufacturing tolerance so you should check that the focus of the Alpy 600 is still correct (refer to the Alpy 600 user guide). From the spectroscopy standpoint, the guided slit is the equivalent of the standard $25\mu\text{m}$ slit (except the width is $23\mu\text{m}$ with guiding module).

Attach the Alpy 600 to the CCD camera, and tune the spectroscopy (focus and orientation - refer to the Alpy 600 user guide).



2.2 Assembling the Alpy 600 and guiding module

Remove the guider external body from the guiding module (loosen the six knurled thumb screws):



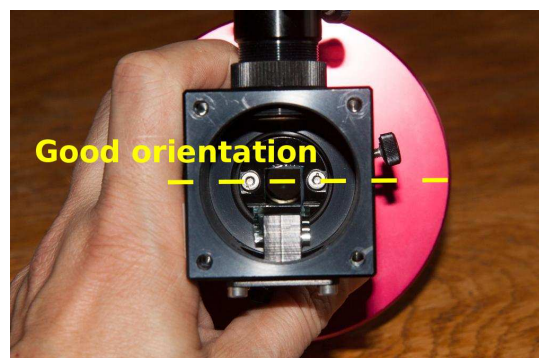
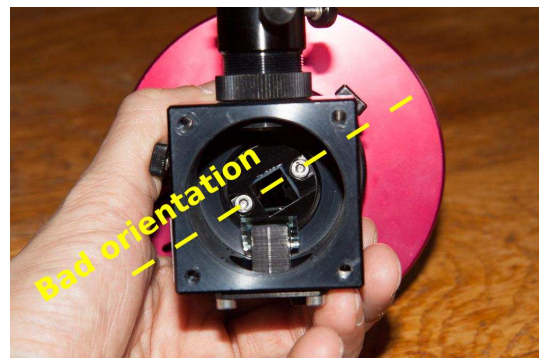
Assemble this part onto the Alpy 600 body - tighten firmly:



Assemble the Alpy 600 on the guiding module.



Rotate the spectroscop in such a way that the slit mirror is towards the guiding mirror (in the images below, the 2" adapter has been removed for a better view):



Push the Alpy 600 fully into the guiding module, and gently tighten the six screws.



Pushing the spectroscope fully in as far as it will go ensures that the slit is at the right position in the guiding module.

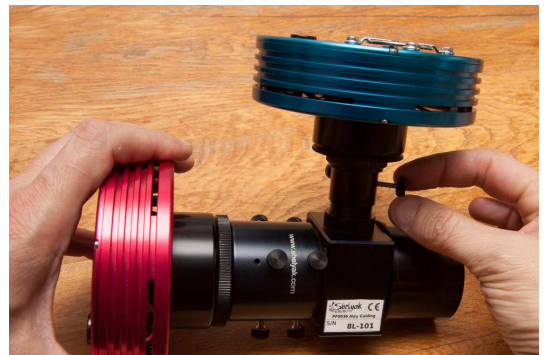
Remove the optics from the guiding module (loosen the two knurled thumb screws):



Mount the guiding camera on the guiding port, and tighten it firmly (the Atik Titan camera below has a T-mount thread - we've added a C-mount to T-mount adapter):



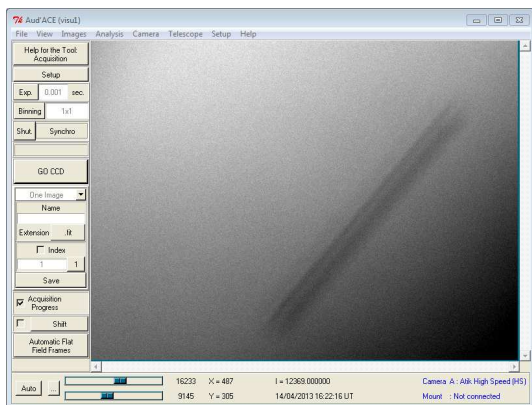
Re-assemble the guiding camera on the module (tighten a little bit the knurled thumb screws):



The Alpy guiding module is ready for use!

2.3 Tuning the guiding camera

Start your PC, and launch the image acquisition software (The screen copies in this document were made with Audela). Take a short exposure of the guiding image. You should have something like this:

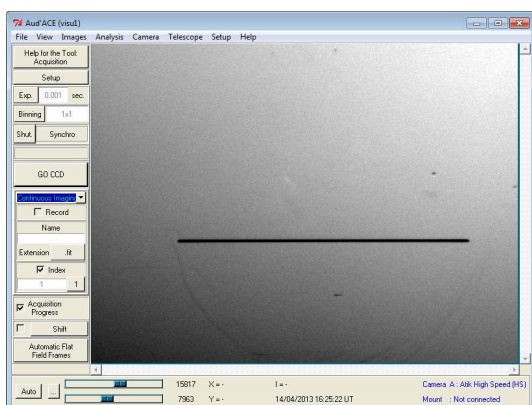


The dark band in the image is the slit, still very unfocused.

Loosen the knurled thumb screws to allow the guiding optics to be rotated and loosen the locking ring to allow focusing:



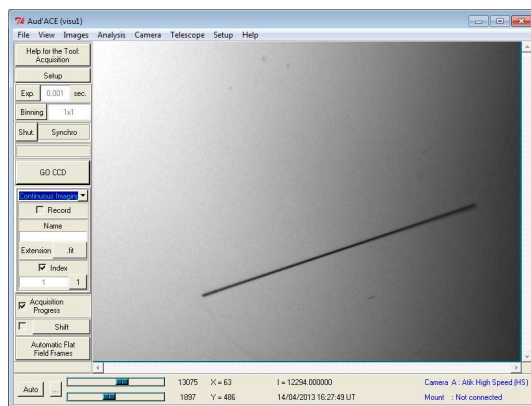
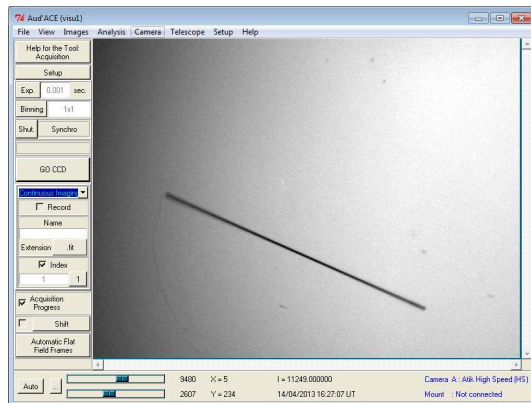
Take continuous images while turning the guiding optics. Try to maintain the camera orientation during this operation to make the image easier to read (it is not comfortable if the image is turning continuously). The slit image should become more and more focused. Eventually you should see it very sharp, and horizontal:



Tighten gently the locking ring and the knurled thumb screws.

Mirror orientation

The slit mirror can rotate around the telescope axis. Optimally, the slit mirror plane must be perpendicular to the guiding module plane (this is the plane formed by the telescope axis and the guiding optics axis). If the slit plane is at an angle, the sky image is sent towards the guiding CCD with the same angle, and the image quality will be poor. Also, you can have significant vignetting:



Tuning this angle is done by rotating the spectro-scope. Slightly loosen the six knurled thumb screws around the external body and adjust while continuously taking images:



The optimal position is when the vignetting is minimal. When you've found it, tighten firmly the six

knurled thumb screws.



It is probable that the slit direction will have moved : rotate the guiding camera to put it back horizontal. If required, re-focus the slit image in this position.



When you rotate the spectroscope, the spectrum remains horizontal in the main CCD camera, because the acquisition camera is firmly attached to the spectroscope.

After all these operations have been done, tighten firmly all the screws and the locking ring.

From now on, the guiding camera will always give you a focused and horizontal image of the slit plane.

2.4 Mounting the spectroscope on the telescope

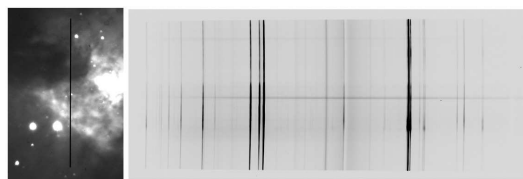
Assembling the Alpy spectroscope on the telescope is an easy part: simply put the 2" nosepiece in the eye-piece holder.



The orientation of the instrument on the telescope should be such that when you move the telescope along the Right Ascension (RA) axis, the image moves across the slit. This is only a question of comfort, but it is easier to center the star in the guiding image if the movements of the telescope are aligned with the axes of the guiding image.

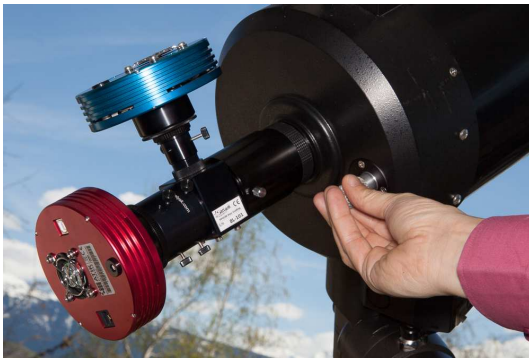


In some special cases, you may decide to orientate the slit in another direction. It might be the case, for instance, for an extended object:



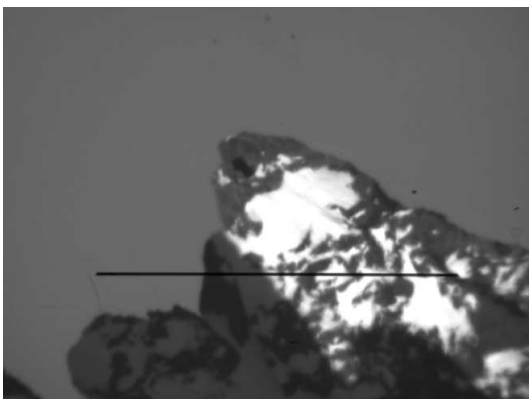
Focusing the telescope

Point the telescope towards an object at the horizon (tree, mountain...), and focus it until you see this object sharp in the guiding image.



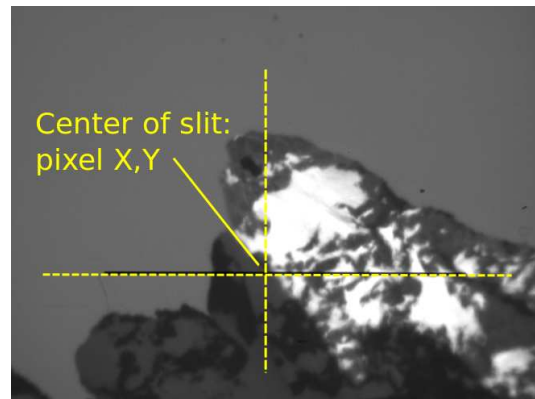
The focus of the slit comes from the guiding camera tuning (which should have been done on the bench). The focus of the object comes from the telescope tuning. When the instrument is ready, both slit & object must be focused in the guiding image.

During daylight, ensure that your finder is aligned with the telescope: it will be much easier to find your target during the night. When an object is in the middle of the guiding image, it must be in the center of your finder.



One final point to check before the night arrives: note where the center of the slit is in the guiding image (pixel X, Y). When night arrives, you don't see the slit in the image any more (it is black on a black

background).



3

Observing with Alpy guiding

Night has arrived, and your installation is now ready for your first star observation.

Cool down your guiding camera (if it is a cooled camera).

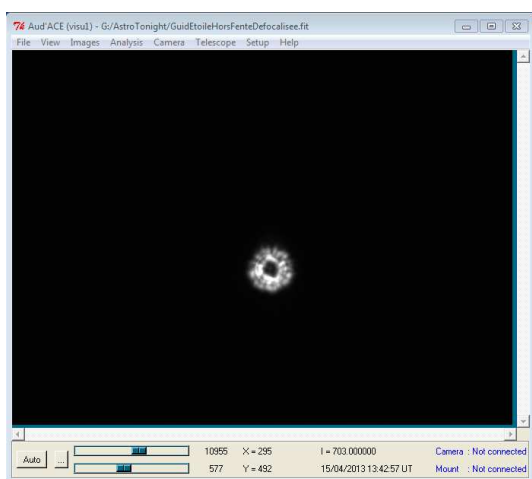
3.1 Putting the star in the guiding field

Point your telescope towards a bright star (magnitude 0 to 3, for instance), high in the sky. Align it precisely with the finder. Take continuous guiding images, with a short exposure time (1 second or less).



In most cases, with a small telescope (200mm or less), a bright star saturates the guiding camera in less than one second.

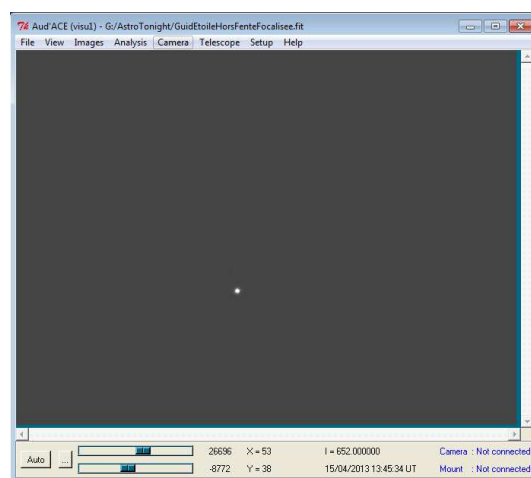
The star should appear in the guiding camera.



If not, move the telescope around slightly. If you still cannot see it, you can unfocus the telescope and increase the exposure time. Unfocusing the star makes it bigger and easier to see in the guiding camera.

When you have “caught the star”, center it in the guiding image and focus it properly. Check also where

exactly the star is in your finder when centered in the guiding image.

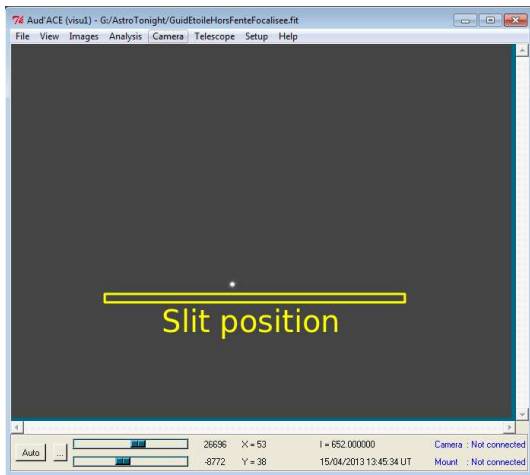


Check the image is not saturated and adjust the exposure time if necessary.

Depending on your setup, the star can be saturated even with the shortest possible exposure time of your guiding camera. In this case, look for a fainter star - in any case, the image must be not saturated for the next steps.

3.2 The star in the slit

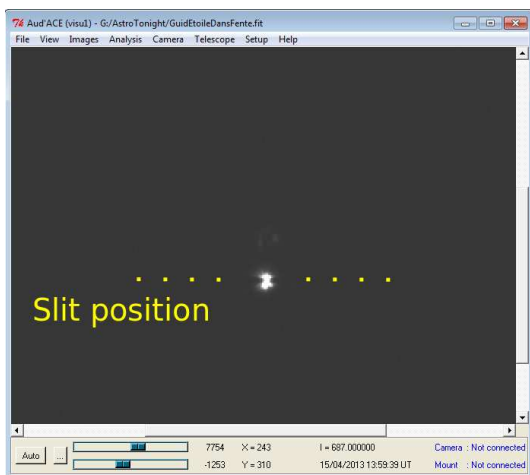
Starlight enters the Alpy 600 spectroscope only when star is in the slit. During the night, you cannot see directly the slit in the guiding image: both background and slit are black.



However, when you move the telescope in such a way that the star crosses the slit, it disappears.

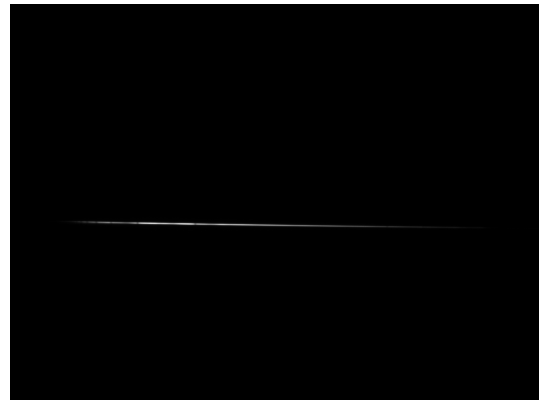


When the starlight disappears from the guiding image, it goes through the spectroscope.



In most cases, there will be always some remaining light in the guiding image. Only very faint objects will totally disappear.

When the star is in the slit, you can take spectra with the Alpy 600 camera (refer to the Alpy 600 user guide). For a bright star (magnitude < 2), it should be saturated in few seconds. As soon as you can see your first spectrum, you can go to the next section.



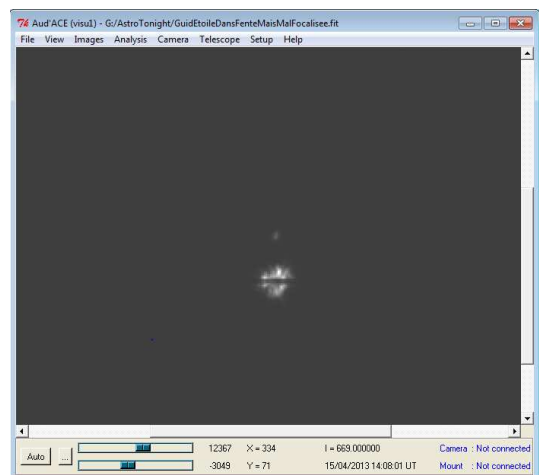
3.3 More light in the spectroscope

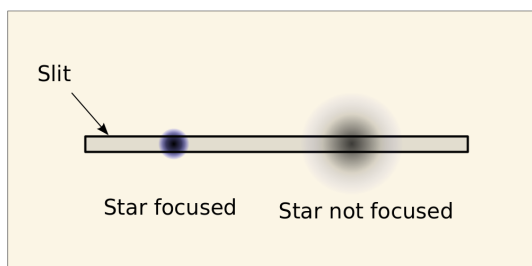
In general, astronomical targets are very faint, and you must maximise the quantity of light entering the spectroscope to improve the quality of your spectrum. A good spectrum is not only a spectrum with the right resolution, but also with a good Signal / Noise Ratio (SNR) for a given exposure time. It is key to understand that it is very easy to lose 90% or more of the light at the slit entrance !

There are three ways to lose light at slit level: bad focus, star not exactly centered in the slit, poor guiding.

Bad focus

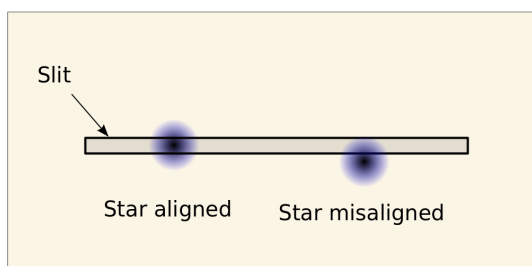
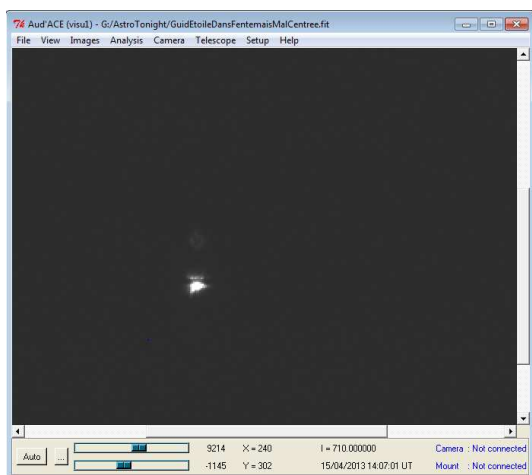
If the telescope is not precisely focused, the star image can be much bigger than the slit. In this case, only part of the starlight enters the spectroscope and the SNR is severely affected:





Star not exactly centered in the slit

The star image depends on your sky's seeing (quality), and on your telescope focal length. In most cases, the image size is of same order as the slit size ($23\mu\text{m}$). The alignment between star image and slit must be precise with only a few μm tolerance, to ensure that maximum light enters the spectroscope. With the configuration used in the document (Atik Titan camera), the slit image is around 3 pixels wide. If we make an error of 1 pixel, it can affect about 30% of the light.



Poor guiding effect

If the telescope mount alignment is not perfect (it is never perfect...), the star will move slightly in the guiding image. Then, it will probably leave the slit and again you'll reduce the level of light entering the spectroscope. This effect may not be significant for bright objects, because exposure times are short. But as soon as you go for fainter objects, guiding becomes

critical. Guiding quality strongly depends on your mount tracking quality and on your guiding parameters. Guiding can be done manually - the observer looks continuously at the guiding image and corrects the telescope position when needed - but you will significantly improve the observation by working with auto-guiding - where the computer does the job, analyzing the image and correcting the telescope position. Auto-guiding is controlled by some parameters (correction thresholds, moving speed), and these parameters must be properly setup for your exact configuration. There is no "general rule" for this setup - it depends mainly on parameters like mount alignment, telescope tracking, wind, seeing.

Global effect

The three effects above are cumulative. If you loose 30% of the light because of focus, 30% because of centering and 30% because of tracking, at the end you'll lose about 66% of the light ($0,7 \times 0,7 \times 0,7 = 0,34$) !

With the experience, you'll get these three effects under control. Just keep in mind that the difference between a poor and a good spectrum often comes from this point.

Here are some keys to improve the SNR of your spectra:

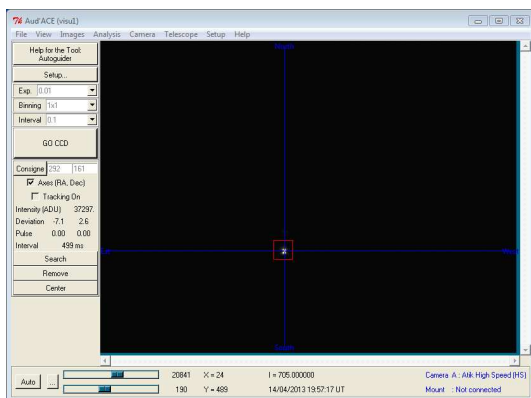
- If the light level at slit is not under control, there will be a significant variation from one spectrum to another. Make a series of spectra, and measure the light level from one image to the next. If it is only few percent, you're fine. But if the variation is above 10%, it means that something is unstable in your setup. It can be a known source (wind or seeing for example), check what can be improved on your instrument.
- Compare your results with others. You will easily find in the forums people with a similar setup to yours. You should get similar results (SNR). Never hesitate to compare your results: our experience shows this is the best way to make significant progress.
- As explained above, when light enters the spectroscope, it disappears from the guiding image. This is true for all three effects (focus, centering, tracking). Then, if your star disappears, it definitely means that your setup is under control. It is important to be able to observe the disappearance of the star: tune the guiding image thresholds in such a way that image is not saturated. Saturation will greatly reduce the change in light level when star is in the slit.



The less light remains in the guiding image, the more light enters the spectroscope and the better is the spectrum.

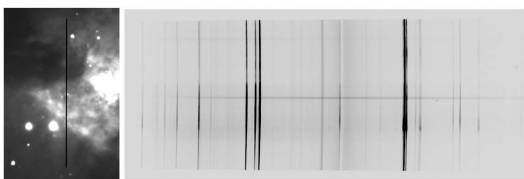
3.4 Put the star (always) in the center of the slit

Here is another tip to improve your observations: always put the star at the same position in the slit, preferably right in the middle - this is the closest point to the instrument axis. By doing this, you will always use your instrument the same way, where the optical performance is best. Repeatability is a key for quality. For this, auto-guiding can also help: if you keep the autoguiding target at the same position, the computer will do the job for you. In the image below, Autoguiding is activated in Audela, and the star remains at the same position X-Y:



3.5 Extended objects

So far, only point-like objects (stars) have been considered. Of course, there are some astronomical objects which are extended : nebulae, galaxies, comets... Observing these objects is easier than stars, because of their surface area. You just need to keep in mind that only the light entering the slit will be analyzed by the spectroscope.



In some cases, you may want to orientate the slit, to adapt it to your target. The rotation must be done with the whole Alpy instrument (Alpy 600 + Alpy guiding), vs the telescope. Don't rotate the guiding camera, or the Alpy 600 camera - this will change the result, but not the way you want.

Rotating the guiding camera will rotate the guiding image, but not the slit direction in the field image,

Rotating the Alpy 600 camera will keep the spectrum unchanged... but it will no longer be horizontal.

Rotating the Alpy 600 in the guiding module means that the field image will no longer be visible in the guiding image.

3.6 Conclusion

You're now ready for high quality observations. Making good observations is not that difficult, but requires combining several elements. This document has described how to get as much light as possible into the spectroscope. The Alpy 600 user guide explains how to proceed to get the best from this light. With experience, you'll go to fainter and fainter objects. Of course, the higher you go in magnitude, the more discoveries you have to make. This is really a never ending story.